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Army Ground Vehicle Use of CFD and Challenges

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Outline

- TARDEC/CASSI Introduction
- Simulation in the Army
- General Challenges
- Types of Analyses
- Working with the Government

TARDEC - Introduction

- Tank Automotive Research, Development and Engineering Center (TARDEC)
  - Develops, integrates, and sustains the technology for all manned and unmanned DOD ground systems
  - The main Research and Development Engineering (R&DE) organization for ground systems integration and technology
- Consists of Three Major Business Groups:
  - Engineering Business Group
  - Product Development Business Group
  - Research Business Group
    - Includes CASSI (Next Slide)

CASSI ANALYTICS

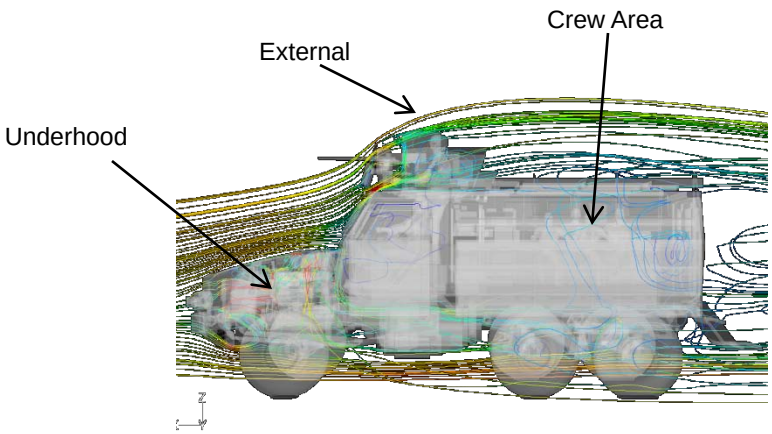
Concepts
Analysis
Systems
Simulation
Integration

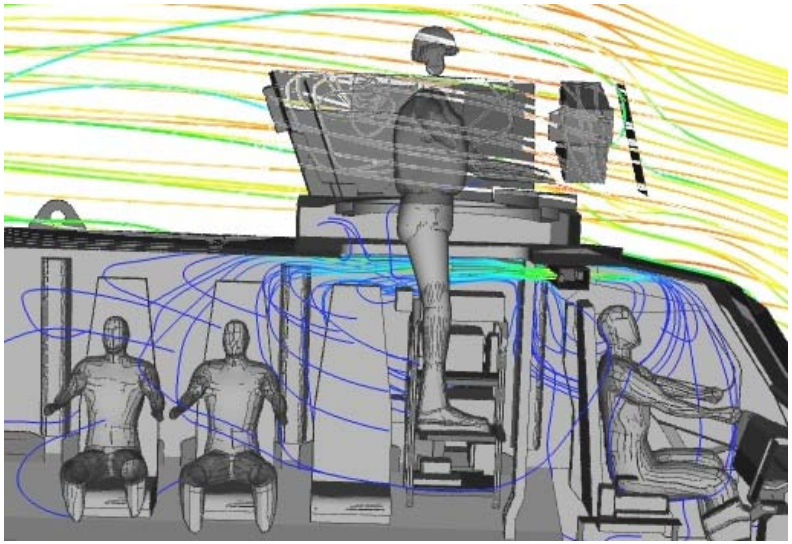
- Why the Army Needs Simulation
  - Pre Specification Work
    - Need to ensure specifications are technically feasible
  - Evaluation of Proposals and Oversight of Supplier Efforts
    - ‘Honest Broker’ - proposed solutions should be evaluated on a level playing field
    - Verify supplier analyses are reasonable
  - Rapid Response for Field Fixes
    - Determine how new equipment will affect vehicle performance
    - Provide initial assessment before starting formal contract process for proposed upgrades
  - Direct R&DE efforts through cooperation with industry
    - Form partnerships to direct development efforts in areas of interest to the Army

General Challenges

- Government does not always own the technical data package
  - May be difficult to get the CAD data
    - Vehicle may have to be scanned
  - System and component performance often not available
    - Flow rates, temperatures, heat rejection information may need to be estimated or measured experimentally
  - Contractors won't or can't share material thermal properties
    - Composite armor stacks
    - Anisotropic conduction
- Data management
  - Long program life cycle means that data needs to be stored and organized for long periods of time
  - Need to tracking a large number of different vehicle configurations and equipment lists
- Data exchange between software packages

Interior Thermal Analysis

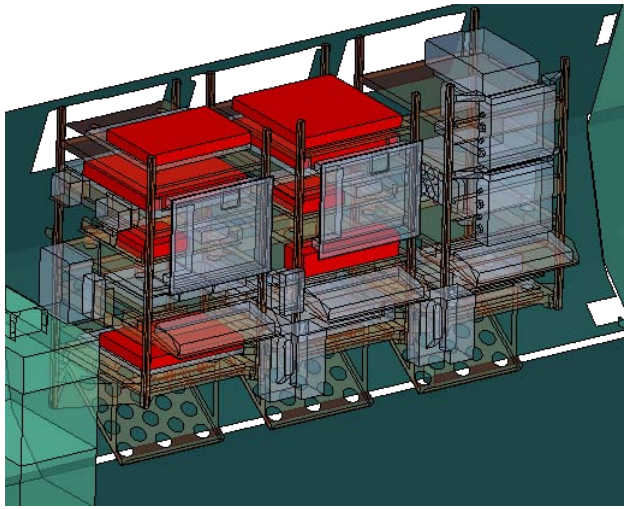




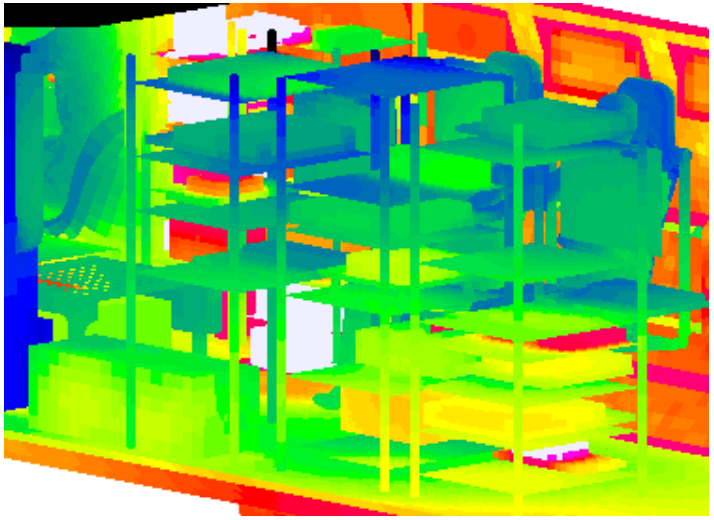
- Harsh environment
  - 30 ºF is 1% day in Iraq
  - 125 ºF in summer
  - In-gear creeping speed
- Up-armored vehicles = heavy
  - Large thermal mass
  - High engine loads = high heat loads
- Open Hatch
- Use of Commercial Equipment
  - Lower temp spec ~95 ºF
- Interested in Cool down Time

Challenge: Perform full transient analysis

Insert Commercial Equipment



Example of a capability add-on
(Equip Pack 2)

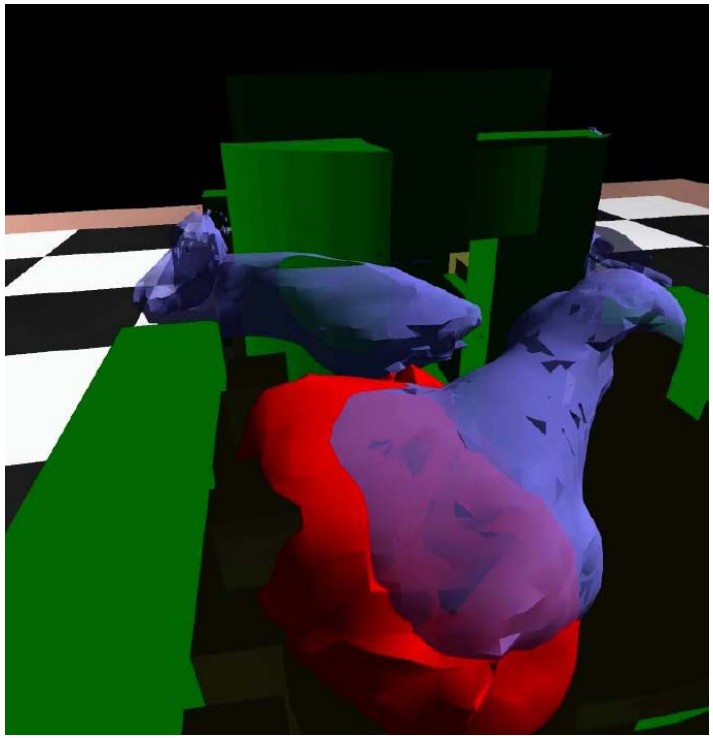


Prediction of equipment temperatures

Challenges:

- When will electronics have a thermal problem?
- Air temperature around equipment or surface temps?
- What are component heat rejection rates/ duty cycles?

Fire Suppression Modeling

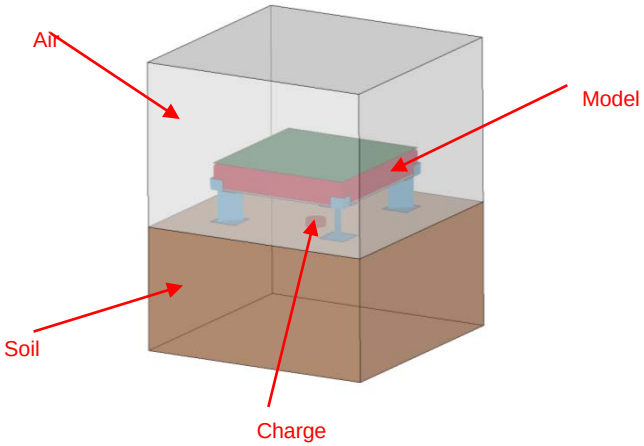


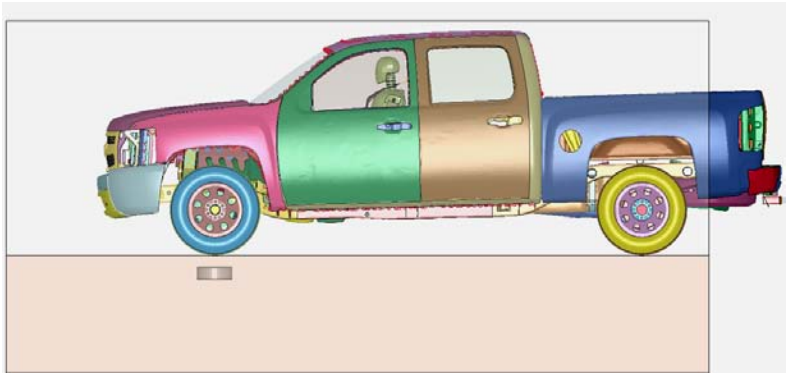
Interaction of flame with suppressing agent

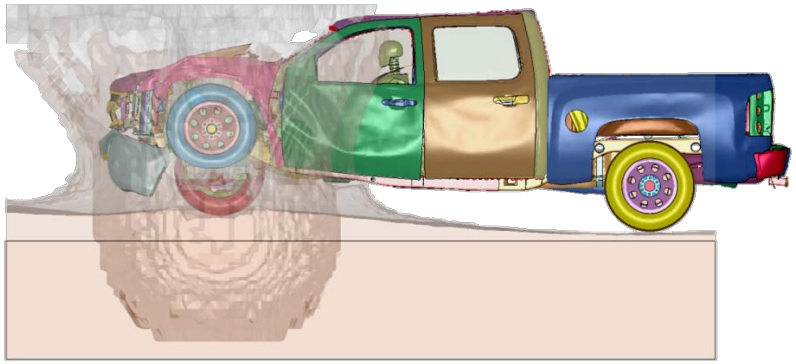
- Goal: Extinguish flame in a fraction of a second
- Place extinguisher bottles into crew area at optimal point
- Challenges:
  - Very deep physics
  - Reacting flows
  - Determine effect on human occupants

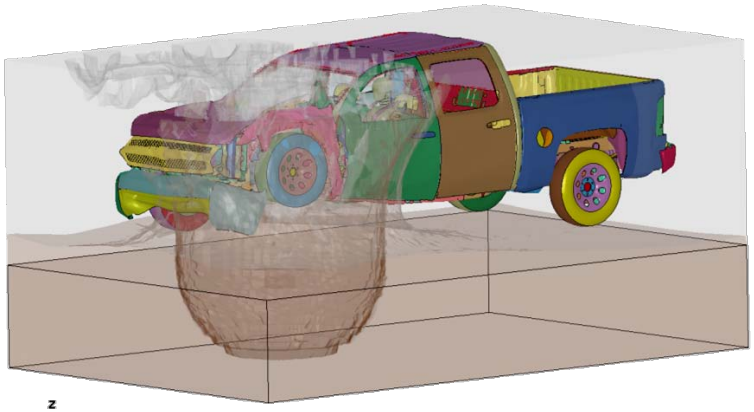
Blast Modeling

- Goal: Predict behavior of structure during mine blast event
  - Improve vehicle survivability
- Challenges:
  - Modeling soil mechanics
  - Fluid-structure interaction with highly deforming mesh
  - Modeling detonation waves

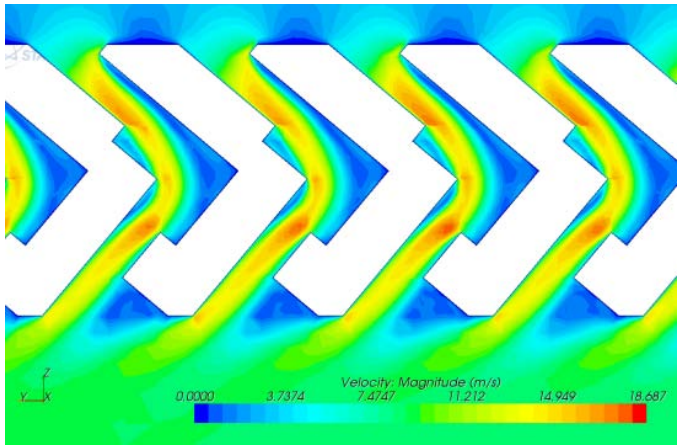


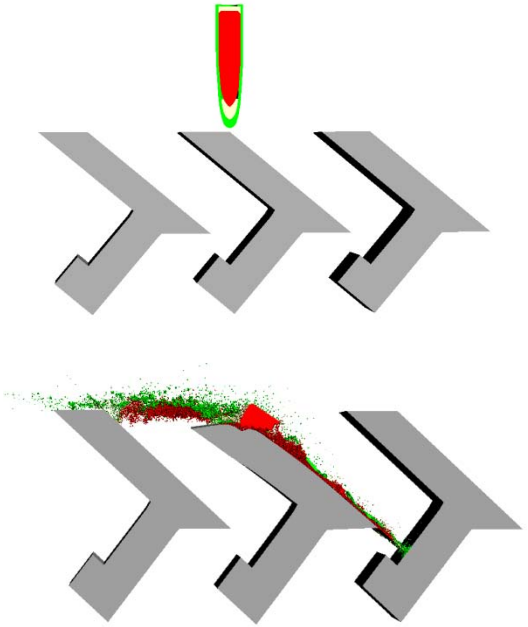






Grille Optimization

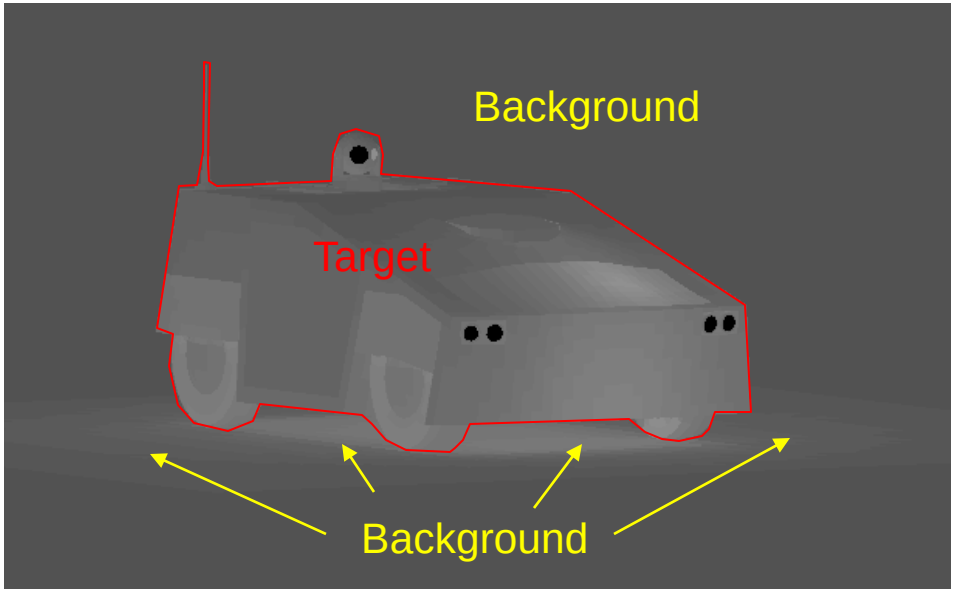


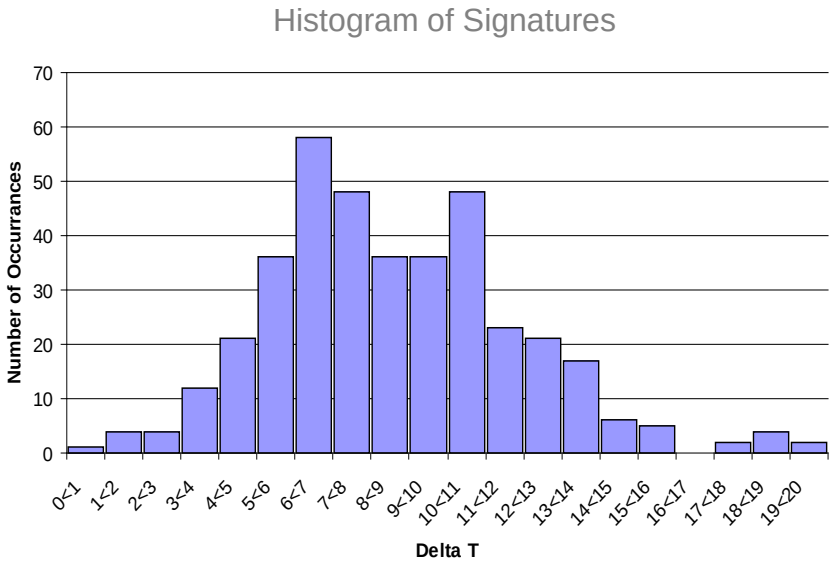


- Multidisciplinary ballistic grille optimizations
- Challenges:
  - Trade-off between ballistics protection, weight, and airflow performance
  - Large amount of cooling airflow through a small area results in high fan power or engine performance degradation

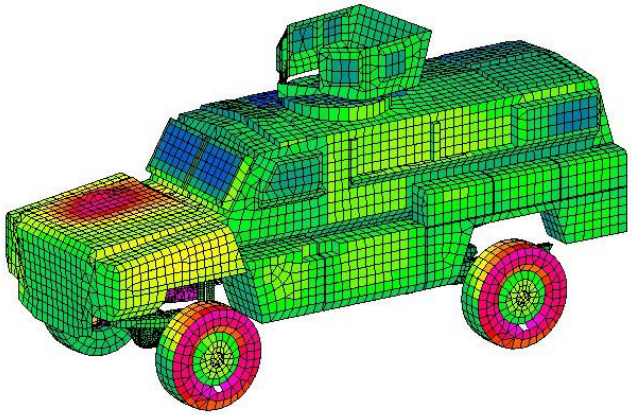
Infrared Signature Modeling

- Delta apparent temperature from the background
- A vehicle does not have a single thermal “signature”
  - Normally plot metrics as histogram
  - Multiple view angles, times, and backgrounds
- Challenge: Calculating updated convection coefficients every 15 minutes using CFD





Thermal Budgeting

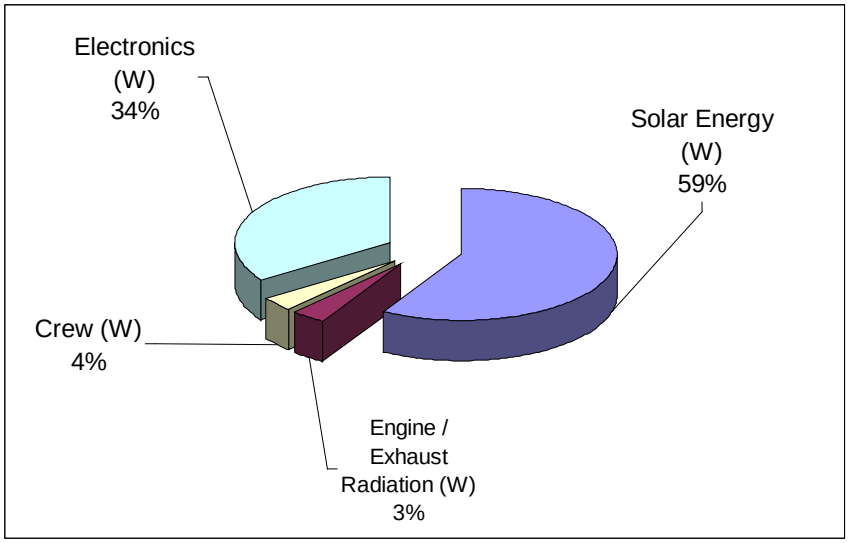


Solar load that strikes exterior:

- **½ is convected away by wind**
- **¼ is radiated away**
- **¼ is conducted to interior**

Solar load that is conducted to interior:

- **2/3 is convected into air**
- **1/3 is radiated toward walls**



Challenge: Identifying best “Bang for the buck” technologies to minimize HVAC size

Other Ground Vehicle CFD Analyses

Specialized Issues

- Exhaust plume modeling
- Amphibious water crossing / fording
- Acoustics signature / silent watch
- Gun tube heating

Automotive Issues

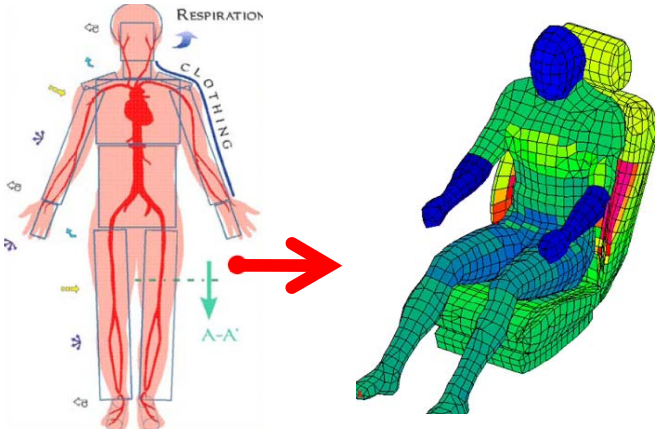
- Under hood Cooling
- HVAC System Design
- Defrost
- Fuel Economy

Working With The Government

- Broad Agency Announcement
  - Certain basic or applied R&D not for any particular vehicle
- Education Partnership Agreement
  - Encourage and enhance study in scientific disciplines at all educational levels
- Ground Vehicle Gateway (GVG)
  - Online portal that will help forward inquiries or proposals directly to NAC or TARDEC researchers
  - https://tardec.groundvehiclegateway.com
- National Automotive Council
  - *Army focal point* for *dual-use automotive/ ground vehicle technology development*
- Small Business Innovative Research Program (SBIR)
  - Tap into the small business community's innovativeness and creativity to help meet government R&D objectives
  - Solicitations posted at: http://www.acq.osd.mil/osbp/sbir/

Example: Working w/ Government

- Need: Predict solider thermal fatigue in CFD models
- Goal: Dual government/industry use
- CRADA (Cooperative Research and Development Agreement)
  - GM shares experience and “lessons learned”
  - TARDEC oversees implementation and pays development
  - Small business entity develops code and sells commercially



Soldier Thermal Fatigue Model

- Implement Berkley Human Comfort Model
- Develop soldier models w/ battle gear
- Metabolic heat rates by role (driver, gunner, commander)
- “Comfort” index generated from local skin temps and body core temp

Conclusion

- TARDEC is actively involved in using CFD in a variety of areas
- TARDEC faces many of the same challenges as the automotive industry
- Partnerships with industry play a large role in advancing technology